Interaction Fields: Sketching Collective Behaviours

Adèle Colas
Inria, Univ Rennes, CNRS, IRISA
adele.colas@inria.fr

Wouter van Toll
Inria, Univ Rennes, CNRS, IRISA
wouter.van-toll@inria.fr

Ludovic Hoyet
Inria, Univ Rennes, CNRS, IRISA
ludovic.hoyet@inria.fr

Claudio Pacchierotti
CNRS, Univ Rennes, Inria, IRISA
claudio.pacchierotti@irisa.fr

Marc Christie
Univ Rennes, Inria, CNRS, IRISA
marc.christie@irisa.fr

Katja Zibrek
Inria, Univ Rennes, CNRS, IRISA
katja.zibrek@inria.fr

Anne-Hélène Olivier
Univ Rennes, Inria, CNRS, IRISA, M2S
anne-helene.olivier@univ-rennes2.fr

Julien Pettré
Inria, Univ Rennes, CNRS, IRISA
julien.pettre@inria.fr

CCS CONCEPTS

• **Computing methodologies → Multi-agent systems**; *Interactive simulation*; *Simulation by animation*; Real-time simulation.

KEYWORDS

animation, user interface, expressivity, intelligent agent, collective behaviour

ACM Reference Format:
Adèle Colas, Wouter van Toll, Ludovic Hoyet, Claudio Pacchierotti, Marc Christie, Katja Zibrek, Anne-Hélène Olivier, and Julien Pettré. 2020. Interaction Fields: Sketching Collective Behaviours. In *MIG2020*. ACM, New York, NY, USA, 2 pages. https://doi.org/10.1145/nnnnnnn.nnnnnnn

1 INTRODUCTION

Many applications of computer graphics, such as cinema, video games, virtual reality, training scenarios, therapy, or rehabilitation, involve the design of situations where several virtual humans are engaged. In applications where a user is immersed in the virtual environment, the (collective) behavior of these virtual humans must be realistic to improve the user's sense of presence. As part of the realism, expressive behaviour appears to be a crucial aspect. For example, Slater et al. [5] showed that the expressive behaviour of an audience in VR had a direct impact on the speaker's performances and perception of themselves. This work concerns the motion through an environment of virtual humans. In the area of crowd simulation, collective behaviours are typically simulated using models based on forces [2], potential fields [6], velocity selection [7], or vision [3]. However, those techniques lack expressiveness and do not allow to capture more subtle scenarios (e.g., a group of agents hiding from the user or blocking his/her way), which require the ability to simulate complex interactions. As subtle and adaptable collective behaviours are not easily modeled, there is therefore a need for more intuitive ways to design such complex scenarios.

In this work, we propose a novel approach to sketch such interactions to define collective behaviours. Although other sketch-based approaches exist, these usually focus on goal-oriented path planning, and not on modelling social or collective behaviour. For instance, Patil et al. [4] proposed a customizable system where users can draw a "guidance" path to lead agents through the scene. However, this guidance is only used to propose a preferred path to the agent and does not involve interactions between agents. In comparison, we present the concepts of a new approach based on a user-friendly application enabling users to draw target interactions between agents through intuitive vector fields (Figure 1). In the future, our goal is to use this approach to facilitate the design of expressive and collective behaviours. By considering more generic and dynamic situations, we design diversified and subtle interactions, which so far have mostly focused on predefined static scenarios [1].

2 INTERACTION FIELDS

In line with crowd-simulation research, we simulate the environment as a 2D plane, and agents as disks whose positions and velocities are 2D vectors. The task of an interaction field (IF) is to describe how agents should move through the environment in the presence of another agent (which we call the *source agent*). An IF is a square with the position of the source agent at its center. Each point in this square prescribes a velocity that other agents should use when they are located there. In practice, we store an IF as a grid, and we compute velocities via interpolation between grid cells. During the simulation, if an agent A is near a source agent S, it will translate and rotate the IF to match the current position and orientation of S. Agent A will then choose the velocity that the IF prescribes for A's current position.

We developed an simple interface enabling a user to intuitively draw the IF for each agent. In this interface, the user can spawn a new agent and its corresponding control vectors are intuitively drawn directly around the source agent. The IF then impacts all the surrounding neighbouring agents of the source to define their interaction with the source of the IF. Then, using interpolation techniques, the interaction field is deduced from the control vectors. Figure 1 shows different examples of IF designed using the

Conference'17, July 2017, Washington, DC, USA

ACM ISBN 978-x-xxxx-xxxx-x/YY/MM…$15.00
https://doi.org/10.1145/nnnnnnn.nnnnnnn

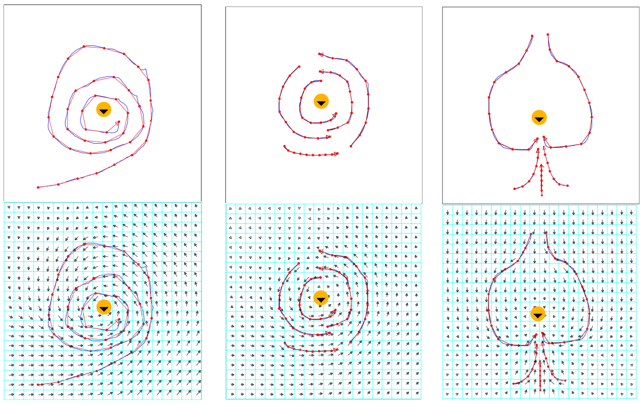

Figure 1: Examples of IF design. Top: the control vectors drawn around the source agent. Bottom: the IFs resulting from the interpolation. Left) Spiral-shape IF. Middle) Circle-shape IF. Right) IF that directs the agents to move in front of the source agent.

interface. The three top figures show an agent (yellow circle) with which other agents are going to interact, the input curves drawn by the user (blue), and their resulting control vectors (red) in three representative trials. The three bottom figures show the resulting IF for the same three trials after interpolation.

3 SIMULATION

In each frame of the simulation, each agent i identifies its neighboring agents, and then each agent i computes a new velocity according to the interaction fields that it applies to each neighbor. For each cell x_k of the grid space of each interaction field IF_k, the vector of the interaction k is:

$$\overrightarrow{x_k} = IF_k(x) \tag{1}$$

We get the final force vector of x for all IFs applied on the scene:

$$\overrightarrow{x} = \sum_k w_k \overrightarrow{x_k} = \sum_k w_k IF_k(x) \tag{2}$$

where w_k is the weight of each interaction field k. Then, to find the acceleration of agent i of mass m_i impacted by the sum of the IFs at each frame of the simulation, we define

$$\overrightarrow{x} = m_i \overrightarrow{a_i} \tag{3}$$

The orientation and the position of the interaction field is updated according to its source agent. Figure 2 shows the resulting simulations of two of the previous designed Interaction Fields (Figure 1(middle) and Figure 1 (right)). The figures are screenshots taken during the simulation involving four agents moving in the same scene, where the three yellow agents' IF impact the surrounding neighbours by a simple repulsion IF (see Figure 2 (left)) representing social distance. The yellow agents' IFs are not displayed for more clarity. The agent in red is moved using the keyboard during the simulation and applies the visible IF to the three other agents. The resulting motion vector is showed in purple for the yellow agents.

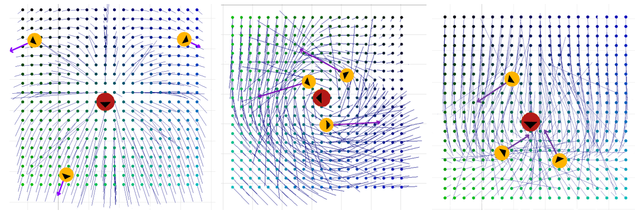

Figure 2: Examples of IF applied by the red agent during a simulation: each yellow agent is moved by the combination of their neighbours' IF (resulting vector in purple). Left) repulsion IF applied by every yellow agent in the pictures. Middle) circle-shape IF designed in Figure 1, middle. Right) the IF applied during simulation designed in Figure 1, right.

4 CONCLUSIONS AND FUTURE WORK

This paper presents our framework to intuitively design interaction fields. It enables users to intuitively draw control shapes around a selected agent, which are then automatically translated into IF acting on the surrounding environment. The fields, weighted, superposed, and agent-centered, modify the surrounding agents' position at each frame of the simulation. This approach to define IFs allows for more flexibility on the modeling of collective behaviors.

To continue our work, we will develop fields applicable to obstacles, groups or objects and work on the combination of IFs. To demonstrate the interest of this work, several evaluations should be conducted, e.g., to test the usability of our interface and their fidelity to the user's intentions, to assert its effectiveness for designing socially-realistic and expressive scenes in VR when a human user is present. The emergent behaviour resulting of the combination of interaction fields should improve the user's presence when interacting with expressive groups.

REFERENCES

[1] Angelo Cafaro, Brian Ravenet, Magalie Ochs, Hannes Högni Vilhjálmsson, and Catherine Pelachaud. 2016. The Effects of Interpersonal Attitude of a Group of Agents on User's Presence and Proxemics Behavior. *ACM Trans. Interact. Intell. Syst.* 6, 2, Article 12 (July 2016), 33 pages.

[2] Dirk Helbing and Peter Molnar. 1998. Social Force Model for Pedestrian Dynamics. *Physical Review E* 51 (05 1998). https://doi.org/10.1103/PhysRevE.51.4282

[3] Axel López, François Chaumette, Eric Marchand, and Julien Pettre. 2019. Character navigation in dynamic environments based on optical flow. *Computer Graphics Forum* 38 (05 2019). https://doi.org/10.1111/cgf.13629

[4] Sachin Patil, Jur van den Berg, Sean Curtis, Ming C. Lin, and Dinesh Manocha. 2011. Directing Crowd Simulations Using Navigation Fields. *IEEE Transactions on Visualization and Computer Graphics* 17, 2 (Feb. 2011), 244–254.

[5] M. Slater, D. . Pertaub, and A. Steed. 1999. Public speaking in virtual reality: facing an audience of avatars. *IEEE Computer Graphics and Applications* 19, 2 (March 1999), 6–9.

[6] Adrien Treuille, Seth Cooper, and Zoran Popović. 2006. Continuum Crowds. *ACM Trans. Graph.* 25, 3 (July 2006), 1160–1168.

[7] Jur van den Berg, Stephen Guy, Ming Lin, and Dinesh Manocha. 2011. *Reciprocal n-Body Collision Avoidance*. Vol. 70. 3–19. https://doi.org/10.1007/978-3-642-19457-3_1